

**KAIZER EFFECT IN ACOUSTIC EMISSION EVENT FROM  
MECHANICAL TESTING**

**MD NURAZLAN BIN MD GHAZALI**

**BACHELOR OF ENGINEERING  
UNIVERSITI MALAYSIA PAHANG**

**2010**

UNIVERSITI MALAYSIA PAHANG

**BORANG PENGESAHAN STATUS TESIS**

JUDUL: **KAIZER EFFECT IN ACOUSTIC EMISSION EVENT  
FROM MECHANICAL TESTING**

SESI PENGAJIAN: 2010/2011

Saya MD NURAZLAN BIN MD GHAZALI (840822-10-5525)  
(HURUF BESAR)

mengaku membenarkan tesis (Sarjana Muda/~~Sarjana~~ /~~Doktor Falsafah~~)\* ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Pahang (UMP).
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. \*\*Sila tandakan ( √ )

**SULIT**

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

**TERHAD**

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

**TIDAK TERHAD**

Disahkan oleh:

\_\_\_\_\_  
(TANDATANGAN PENULIS)

\_\_\_\_\_  
(TANDATANGAN PENYELIA)

Alamat Tetap:

Nama Penyelia:

**27, JALAN KERIS 7,  
TAMAN PUTERI WANGSA,  
81800 ULU TIRAM,  
JOHOR.**

**CHE KU EDDY NIZWAN BIN  
CHE KU HUSIN**

Tarikh: **06 DISEMBER 2010**

Tarikh: **06 DISEMBER 2010**

CATATAN:\*  
\*\*

Potong yang tidak berkenaan.  
Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai atau TERHAD.  
Tesis dimaksudkan sebagai tesis bagi Ijazah doktor Falsafah dan Sarjana secara Penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

KAIZER EFFECT IN ACOUSTIC EMISSION EVENT FROM MECHANICAL  
TESTING

MD NURAZLAN BIN MD GHAZALI

Report submitted in partial fulfilment of the requirements  
for the award of the degree of  
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering  
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

**UNIVERSITI MALAYSIA PAHANG**  
**FACULTY OF MECHANICAL ENGINEERING**

I certify that the thesis entitled “*Kaizer Effect in Acoustic Emission Event from Mechanical Testing*” is written by *Md Nurazlan Bin Md Ghazali*. I have examined the final copy of this thesis and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Mechanical Engineering. I herewith recommend that it be accepted in fulfilment of the requirements for the degree of Mechanical Engineering.

Mr Abdul Rahim Bin Ismail  
Lecturer Faculty of Mechanical Engineering  
Universiti Malaysia Pahang

Signature

### **SUPERVISOR'S DECLARATION**

I hereby declare that I have checked this project report and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature:

Name of Supervisor: CHE KU EDDY NIZWAN BIN CHE KU HUSIN

Position: Lecturer Faculty of Mechanical Engineering

Date: 6 DECEMBER 2010

**STUDENT'S DECLARATION**

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature:

Name: MD NURAZLAN BIN MD GHAZALI

ID Number: MA08019

Date: 6 DECEMBER 2010

## TABLE OF CONTENTS

		<b>Page</b>
<b>APPROVAL DOCUMENT</b>		ii
<b>SUPERVISOR'S DECLARATION</b>		iii
<b>STUDENT'S DECLARATION</b>		iv
<b>ACKNOWLEDGEMENTS</b>		vi
<b>ABSTRACT</b>		vii
<b>ABSTRAK</b>		viii
<b>TABLE OF CONTENTS</b>		ix
<b>LIST OF TABLES</b>		xii
<b>LIST OF FIGURES</b>		xiii
<b>LIST OF SYMBOLS</b>		xviii
<b>LIST OF ABBREVIATIONS</b>		xix
<b>CHAPTER 1 INTRODUCTION</b>		
1.1	Project Background	1
1.2	Problem Statement	2
1.3	Objectives	3
1.4	Hypothesis	3
1.5	Scopes of Research	4
<b>CHAPTER 2 LITERATURE REVIEW</b>		
2.1	Introduction	5
2.2	Mechanical Testing	5
	2.2.1 Tensile Test	6
	2.2.2 Testing Machine for Tensile Test	6
	2.2.3 Tensile Specimen	7
	2.2.4 Stress-Strain Curve	8
	2.2.5 Fracture Characteristics of Tested Specimens	14
	2.2.6 Torsion Test	16
	2.2.7 Torsion Specimen and Testing Machine	17
	2.2.8 Fundamental Principles of the Torsion Test	19

2.2.9	Fracture Characteristic of Tested Specimen	24
2.3	Types of Materials	26
2.3.1	Aluminum and Aluminum Alloys	26
2.3.2	Chemical Composition	26
2.3.3	Specification of Aluminum	27
2.3.4	Mild Steel	28
2.3.5	Characteristic of Mild Steel	29
2.4	Acoustic Emission (AE)	30
2.4.1	Introduction to the Acoustic Emission	30
2.4.2	Concept of Acoustic Wave Propagation	31
2.4.3	Parameter of Acoustic Emission (AE) Signal	32
2.4.4	Kaiser Effect and Felicity Effect	34
2.5	Equipment Used in AE Monitoring	35
2.5.1	Sensor	35
2.5.2	Couplant and Holders	36
2.5.3	Pre-Amplifiers	36
2.5.4	Data Acquisition System	36
2.6	AE Signal Parameter Analysis	37
2.7	Application of Acoustic Emission	39

### **CHAPTER 3      METHODOLOGY**

3.1	Introduction	41
3.2	Project Flow Chart	42
3.3	Literature Review	43
3.4	Material Selection	43
3.5	Sample Preparation	44
3.6	Acoustic Emission Test Setup	47
3.6.1	Testing Procedure	47
3.6.2	Test Setup	48
3.6.3	Sensor Calibration Test	51
3.6.4	Loading Profile	52
3.7	Data Flow Analysis	53



## **CHAPTER 4      RESULT AND DISCUSSION**

4.1	Introduction	56
4.2	Tensile Test Experiment	56
4.3	Torsion Test Experiment	61
4.4	Discussion	65
	4.4.1 Hits Data for Aluminum Material	65
	4.4.2 Energy Data for Aluminum Material	67
	4.4.3 RMS Data for Aluminum Material	69
4.5	Mild Steel Specimen	70
	4.5.1 Hits Data for Mild Steel Material	70
	4.5.2 Energy Data for Mild Steel Material	72
	4.5.3 RMS Data for Mild Steel Material	73

## **CHAPTER 5      CONCLUSION AND RECOMMENDATION**

5.1	Conclusion	76
5.2	Recommendation	77

<b>REFERENCES</b>	78
-------------------	----

<b>APPENDICES</b>	80
-------------------	----

<b>A1-A8</b>	AE Data for each experiment	80
--------------	-----------------------------	----

<b>B1</b>	MATLAB cording for acoustic emission data analyzing	112
-----------	---	-----

<b>C1</b>	Gantt Chart	113
-----------	-------------	-----

**LIST OF TABLES**

<b>Table No.</b>	<b>Title</b>	<b>Page</b>
2.1	Dimensional relationships of tensile specimen used in various countries	8
2.2	Properties of selected aluminum alloys at room temperature	28
2.3	Composition of mild steel	29
2.4	Standard properties of mild steel	29
3.1	Details dimension for tensile specimen	46
3.2	Detail dimension for torsion specimen	47
3.3	Loading schedule for tensile test	53
3.4	Loading schedule for torsion test	53

## LIST OF FIGURES

<b>Figure No.</b>	<b>Title</b>	<b>Page</b>
2.1	UTM Tensile Test Apparatus (electromechanical)	7
2.2	Standard tensile specimen	8
2.3	Stress-strain relationship under uniaxial tensile loading	9
2.4	Stress-strain curve of low carbon steel and aluminum	11
2.5	Determination of the yield strength at 0.2% offset	12
2.6	Necking of a tensile specimen occurring prior to fracture	13
2.7	Cup and cone fracture	15
2.8	Ductile fracture surface	15
2.9	Brittle fracture surface	15
2.10	Torsion in cylindrical bar	16
2.11	Torsion testing machine	17
2.12	Torsion specimen	18
2.13	Schematic diagram of torsion test	18
2.14	Relationship between torque and angle twist	19
2.15	Torsion of a solid bar	20
2.16	Relationship between modular shear stress and shear strain	23
2.17	Types of failure in torsion	24
2.18	Fracture surface of a driveshaft in brittle under torsion	25
2.19	Fracture surface of driveshaft in ductile under torsion	25
2.20	Principle of acoustic emission	31
2.21	Transient signal	32
2.22	Continuous signal	32

2.23	A typical AE signal	33
2.4	Stress-strain curve of low carbon steel and aluminum	11
2.5	Determination of the yield strength at 0.2% offset	12
2.6	Necking of a tensile specimen occurring prior to fracture	13
2.7	Cup and cone fracture	15
2.8	Ductile fracture surface	15
2.9	Brittle fracture surface	15
2.10	Torsion in cylindrical bar	16
2.11	Torsion testing machine	17
2.12	Torsion specimen	18
2.13	Schematic diagram of torsion test	18
2.14	Relationship between torque and angle twist	19
2.15	Torsion of a solid bar	20
2.16	Relationship between modular shear stress and shear strain	23
2.17	Types of failure in torsion	24
2.18	Fracture surface of a driveshaft in brittle under torsion	25
2.19	Fracture surface of driveshaft in ductile under torsion	25
2.20	Principle of acoustic emission	31
2.21	Transient signal	31
2.22	Continuous signal	32
2.23	A typical AE signal	32
2.24	Plot illustrating cycling loading and breakdown of the Kaiser Effect	34
2.25	Common types of AE sensor	35

2.26	Magnetic holder	36
2.27	Data Acquisition system	37
2.28	Cumulative plot of events v/s time	38
2.29	Plot of load history along with cumulative hits	38
3.1	Project flow chart	42
3.2	Types of material	43
3.3	Shearing machine	44
3.4	Die set for tensile specimen	44
3.5	Stamping process	45
3.6	Engineering drawing for tensile test specimen	45
3.7	Lathe machine	46
3.8	Torsion specimen	47
3.9	USB-AE-Node unit	48
3.10	Integral preamplifier AE piezoelectric sensor	48
3.11	Detail of the AE test setup from tensile testing	49
3.12	Detail of the test setup for torsion test	50
3.13	Mild steel adaptor for torsion test	50
3.14	Aluminum adaptor for torsion test	50
3.15	Pencil break calibration	51
3.16	Stress schedule for Kaiser Effect	53
3.17	The AE flow process analysis	54
4.1	First experiment for aluminum tensile test	57
4.2	Hits and energy from first experiment for aluminum tensile test	57
4.3	Second experiment for aluminum tensile test	57

4.4	Hits and energy from second experiment for aluminum tensile test	58
4.5	First experiment for mild steel tensile test	59
4.6	Hits and energy from first experiment for mild steel tensile test	59
4.7	Second experiment for mild steel tensile test	60
4.8	Hits and energy from second experiment for mild steel tensile test	60
4.9	First experiment for aluminum torsion test	61
4.10	Hits and energy from first experiment for aluminum torsion test	62
4.11	Second experiment for aluminum torsion test	62
4.12	Hits and energy from second experiment for aluminum torsion test	63
4.13	First experiment for mild steel torsion test	63
4.14	Hits and energy from first experiment for mild steel torsion test	64
4.15	Second experiment for mild steel torsion test	64
4.16	Hits and energy from second experiment for mild steel torsion test	65
4.17	Force and data hit versus time for aluminum tensile test experiment	66
4.18	Force and data hit versus time for aluminum torsion test experiment	67
4.19	Force and energy versus time for aluminum tensile experiment	68
4.20	Force and energy versus time for aluminum torsion experiment	68
4.21	Force and RMS versus time for aluminum tensile experiment	69
4.22	Force and RMS versus time for aluminum torsion experiment	70
4.23	Force and data hit versus time for mild steel tensile test experiment	71
4.24	Force and data hit versus time for mild steel torsion test experiment	71
4.25	Force and energy versus time for mild steel tensile test experiment	72

4.26	Force and energy versus time for mild steel torsion test experiment	73
4.27	Force and RMS versus time for mild steel tensile test experiment	73
4.28	Force and RMS versus time for mild steel torsion test experiment	74

**LIST OF SYMBOLS**

mm	Millimeter
Mps	Megapascal
$M_T$	Torsion moment
GPa	Gigapascal
%	Percent
kN	Kilonewton
Nm	Newton meter
kHz	Kilohertz
$\sigma$	Stress
$P$	Load
$A_0$	Cross sectional area
$e$	Strain
$l$	Instantaneous length
$l_0$	Original length
$E$	Modulus of elasticity
$dB$	Decibel
Vs	Energy
Nm	Torque



**LIST OF ABBREVIATIONS**

UMP	University of Malaysia Pahang
FKM	Fakulti Kejuruteraan Mekanikal
ASTM	American Society for Testing and Material
AISI	American Iron and Steel Institute
NDT	Nondestructive Testing
AE	Acoustic Emission
RMS	Root Mean Square